STATUS OF ROOSEVELT ELK (*Cervus elaphus roosevelti*) IN BRITISH COLUMBIA

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BRITISH COLUMBIA

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ABSTRACT

The Roosevelt or Olympic Elk (*Cervus elaphus roosevelti* Merriam) is one of four subspecies of Elk that have occurred in Canada. *C.e. roosevelti* is larger and has darker pelage and more massive, rugged antlers than other members of the species.

Roosevelt Elk occur in coniferous forests of all ages, as well as in deciduous stands and nonforested habitats, such as wetlands and vegetated slides and rock outcrops. They currently range in a discontinuous pattern along the Pacific coast from San Francisco, California, north to Vancouver Island, extending as far inland as the summit of the Cascade mountain range. Most of their historic range is occupied by humans, which effectively fragments it and isolates many local populations.

Although Roosevelt Elk were historically more widely distributed, in Canada they are currently found only on Vancouver Island and in some watersheds in southwestern British Columbia. The current distribution is largely a result of historic market hunting and forestry activities, as well as of later translocation efforts to expand the Elk's range. Most of Canada's Roosevelt Elk occur on northern Vancouver Island.

Before this review, the best and most current estimate of Roosevelt Elk numbers in British Columbia was between 2650 and 4350. A more detailed analysis suggests an estimate of 3660 Roosevelt Elk in British Columbia, approximately 65% of which are mature animals with the potential to breed. Most of the province's Roosevelt Elk, some 3300 animals, occur on Vancouver Island where they form two metapopulations. The finite rate of increase for Elk on Vancouver Island suggests stability, and local population estimates also imply that Roosevelt Elk in British Columbia are stable to increasing throughout their distribution.

Despite the apparent current stability of Roosevelt Elk on Vancouver Island, future declines in Elk numbers are expected because of their vulnerability to habitat modification, predation, linear disturbance, and unregulated hunting. Several sources of information suggest a negative overall picture of the status and trend of Roosevelt Elk winter habitat in British Columbia, which has been degraded by industrial forestry. Habitat protection is improving, although the absolute area of protected winter range is currently difficult to determine and is not expected to exceed a small amount of high-capability habitat in the near future.

Management recommendations include conducting a habitat supply analysis, implementing benign silvicultural practices, continuing conservative hunting allocations, considering management implications at the ecosystem level, and continuing translocation programs.

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SPECIES INFORMATION

Name and Classification

The species *Cervus elaphus* Linnaeus 1758 includes both Eurasian red deer and North American Elk or wapiti. These populations have been separated for a relatively short period (about 10 000 years) and may interbreed to produce reproductive offspring. Although the shared taxonomy between New World and Siberian populations has been the subject of some controversy, most taxonomists now consider them to be a single species (Bryant and Maser 1982; Nagorsen 1990).

Six subspecies of Elk are recognized to have existed in North America since the arrival of Europeans; two of these (*C.e. merriam* and *C.e. canadensis*) are extinct. A comprehensive study of the geographic variation of North American Elk has never been completed, leading some authors to question the validity of these six currently defined subspecies (Groves and Grubb 1987).

The Roosevelt or Olympic Elk (*Cervus elaphus roosevelti* Merriam) is one of four subspecies of Elk, including the Manitoban Elk (*C.e. manitobensis*), the Rocky Mountain Elk (*C.e. nelsoni*), and the extinct Eastern Elk (*C.e. canadensis*), that have occurred in Canada (Bryant and Maser 1982). The subspeciation of Roosevelt Elk is believed to be a product of isolation. One theory suggests that Elk, moving southward and westward in response to the advance of the Wisconsin glaciation, extended the species' range into the vicinity of the Oregon–California border. From there, they moved northward into western Oregon, where they became isolated behind the barrier of the Cascade Mountains to the east (McCullough 1969; Bryant and Maser 1982). Recent genetic analysis supports the classification of the Roosevelt subspecies (Polziehn et al. 1998).

Description

The Elk is a large member of the deer family, characterized by a dark head and neck and a distinctive yellow-brown or cream-coloured rump patch and short tail bordered by a dark brown or black stripe (Figure 1). Large males may reach more than 400 kg, while females are considerably smaller at approximately 250 kg (Bryant and Maser 1982; Shackleton 1999). (One bull relocated on the Mainland weighed 461 kg after antlers were removed; D. Reynolds, Ministry of Water, Land and Air Protection, Sunshine Coast, B.C., pers. comm.). Antlers are grown by males and may range from simple spikes and forks on yearlings to large branched structures on mature bulls, typified by a brownish main beam more than a metre long with five or six ivory-tipped tines. Antlers are typically shed from March through May, generally older males drop their antlers first and younger animals later. Elk and caribou are the only North America ungulates that have canine teeth (Shackleton 1999).

The Roosevelt Elk is the largest of the North American subspecies of Elk. It has a noticeably dark body colour that appears reddish-brown in summer, lightening in winter to a creamy colouration on bulls and grayish-brown hues on cows. Roosevelt Elk have more massive, rugged antlers that are often shorter than in other subspecies, but antlers may be flattened

Figure 1. A Roosevelt Elk on Vancouver Island (photo by Doug Janz, Nanaimo).

or even form a crown-like structure of three or four points at the terminus.

Nationally Significant Populations

This report is concerned with the entire range of *C.e. roosevelti* in Canada.

DISTRIBUTION

Global Range

Roosevelt Elk currently range in a discontinuous pattern along the Pacific coast from San Francisco, California, north to Vancouver Island, extending as far inland as the summit of the Cascade mountain range (Figure 2). A local population of Roosevelt Elk, introduced in 1927, also occurs on Afognak Island in Alaska. Roosevelt Elk populations are believed to be secure in the United States, including Washington, where Elk occur on the Olympic Peninsula, 50 km from Vancouver Island across Juan de Fuca Strait. Recent genetic analysis suggests that Elk on the Olympic Peninsula are less genetically "pure" than those on Vancouver Island (Polziehn et al. 1998). Vancouver Island Elk appear to be monophyletic (i.e., derived from a single lineage) and have maintained

Figure 2. Current global distribution of Roosevelt Elk. The speckled polygon represents the overall range, but this distribution is fragmented and discontinuous. The introduced local population on Afognak Island, Alaska, is not shown. (Adapted from Bryant and Maser 1982)

this characteristic as a product of their isolation. Elk from Olympic National Park have similarly unique genetic qualities, but also include genetic traits characteristic of Rocky Mountain Elk. The latter subspecies are abundant in Washington and within reasonable travelling distance of the peninsula. It is possible that interbreeding between the subspecies has taken place due to transplants of the Rocky Mountain subspecies into coastal areas during the early 1900s.

The broad-scale distribution of Roosevelt Elk has changed little compared with other subspecies of Elk. However, most of the historic range of Roosevelt Elk is now occupied by humans, which effectively fragments its range and isolates many local populations. Hunting for meat and hides during the gold rushes of the mid-1800s is considered to be a major factor in the extermination of Elk in the southern portion of their range (Harper et al. 1967).

Canadian Range

In Canada, Roosevelt Elk are found on Vancouver Island and some pockets of the southwest Mainland (approximately 23 000 km^2 of occupied habitat; Figure 3). Although Elk were historically more widely distributed in coastal British Columbia (Cowan and Guiguet 1965), human settlement and market hunting have led to their extermination from possibly all of the Mainland and parts of southern Vancouver Island (Brunt 1990). Much of this status report will focus on the Elk of Vancouver Island, because these represent most of the Elk in the province and Vancouver Island is the core of the current range. Roosevelt Elk are currently on the provincial "blue list" of species that are considered vulnerable to human activities.

From the 1850s, when the first Europeans arrived, until the end of the nineteenth century, Elk were locally abundant on Vancouver Island and distributed on at least several neighbouring Gulf Islands (based on skeletal remains). However, by the early twentieth century, Elk numbers were low enough to result in hunting season closures and predator control programs on Vancouver Island (Spalding 1992). Currently, Elk on Vancouver Island occupy most forested areas, but are rare or absent in large areas around urban centres at Victoria and Nanaimo and along the west coast north to the Brooks Peninsula. The result is two distinct, but not discrete, metapopulations separated roughly by Alberni Inlet; one in the south island, centred between Cowichan Lake and the Nanaimo River watershed, and a second in the north, a rectangle with corners at Woss, Gold River, Campbell River, and the Tsitika River. The larger, north Island metapopulation contains most of Canada's Roosevelt Elk. It has been subject to some growth, which has resulted in "infilling" of unoccupied habitats since 1900 (Janz and Becker 1986). Elk no longer occur on the southern Gulf Islands, although tracks and single animals are rarely sighted on islands in the northern portion of the Strait of Georgia, including Denman, Quadra, and West Cracroft islands (Spalding 1992).

Roosevelt Elk are also concentrated in several local populations along the southwest Mainland (Shackleton 1999). Currently, the concentration of animals located near Phillips Arm is possibly the only remaining local population native to mainland British Columbia (J. Evans, Ministry of Water, Land and Air Protection, Surrey, B.C., pers. comm.). The delineation of the Roosevelt Elk's historic distribution on the Mainland is not well described; however, reports from the first Europeans in the area describe abundant Elk during the early 1800s, with very few apparently remaining by the late 1800s (Spalding 1992). Chief Capilano described killing 13 Elk near present-day False Creek in Vancouver in the mid-1800s (Spalding 1992), and native bands as far north as Bella Coola (on the coastal mainland, about 150 km north of the tip of Vancouver Island) possess well-developed hunting techniques for Elk, similar to those used by other bands in the Pacific Northwest (McCabe 1982). Based on our current knowledge of the historic distribution of *Cervus elaphus*, Bella Coola hunters would have had a long journey inland to find Rocky Mountain Elk, so it is easy to speculate that their hunting techniques came from stalking the Roosevelt subspecies. If this provides an indication of the northern extent of Roosevelt Elk range in the 1850s, it would suggest that current Elk range in British Columbia is considerably less than it was 150 years ago.

Translocations of Elk have played a considerable role in determining their distribution both on and off Vancouver Island. Approximately 87 animals have

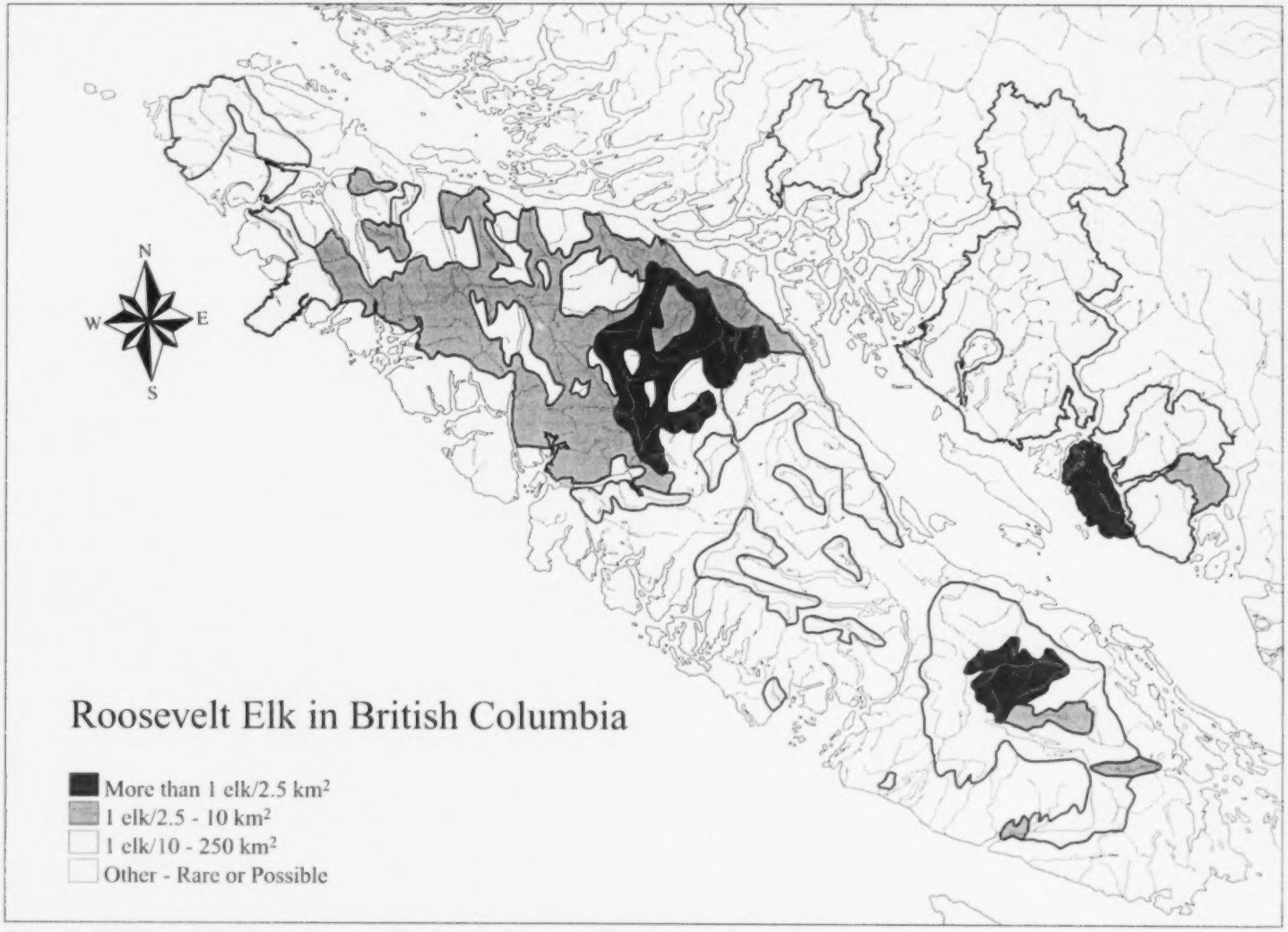

Figure 3. Canadian distribution of Roosevelt Elk. Shading represents expected density of Elk. (Source: BC Ministry of Water, Land and Air Protection.)

been moved between watersheds on Vancouver Island in an effort to infill and strengthen linkages within the existing range (K. Brunt, unpubl. data). Another effort was the reintroduction of animals from Vancouver Island to the Lower Mainland. Three Elk transplants occurred between 1987 and 1989 in which a total of 22 animals were moved from Vancouver Island to the Kleindale area on the Sechelt Peninsula. The Peninsula local population has since grown to provide a convenient source of Roosevelt Elk for transplantation into mainland watersheds within the area from which Elk had been extirpated. In 1996, 25 Elk were captured near the transplant site at Kleindale and relocated to the Lois River area near Powell River. In early 2001, an additional 32 Elk were transplanted from Kleindale to the McNab Creak drainage with the help of the Sunshine Coast Rod and Gun Club, and in 2002, transplanting continues with 16 more Elk from Kleindale and 7 from the Powell River area moved to the Tzoonie and Skwawka watersheds (D. Reynolds, pers. comm.).

Although Elk are found in the Queen Charlotte Islands, these are not Roosevelt Elk, but the product of introductions of the now extirpated European red deer (*C.e. elaphus*) and Rocky Mountain Elk (Spalding 1992). In the Lower Mainland, Rocky Mountain Elk are also found south of the Chilliwack River, east of the range of Roosevelt Elk (Shackleton 1999).

HABITAT

Habitat Requirements

In the Pacific Northwest, where water is abundant, Elk habitat is most pragmatically thought of in terms of food and cover. Elk focus their habitat use on edges between relatively open areas that provide forage and densely forested areas that provide cover (Skovlin 1982). Elk occur in coniferous forests of all ages, as well as deciduous stands and nonforested habitats such as wetlands, vegetated slides, and rock outcrops. The understorey type, successional stage, and forest history influence the quantity and quality of food available in forested habitats. On Vancouver Island, habitats for optimal feeding can generally be characterized by moist, rich soils that ensure an abundance of preferred food species. These habitats include:

- open conifer stands (<70% canopy closure),
- stands dominated by deciduous trees (>50% deciduous),
- non-forested wetlands (seepages, estuaries, wetlands),
- riparian areas,
- vegetated slides on summer ranges, and
- borders of south-facing rock outcrops on winter and spring ranges.

Energy and protein are derived by Elk from forage. The energy available to Elk from their forage depends on the digestibility of the dry matter in the plants eaten. Both dry matter digestibility and protein content vary throughout the year, declining to their lowest points in winter. In a moderately severe winter on Vancouver Island, dry matter digestibility may actually fall as low as 32% (Janz 1983), no longer meeting the minimum 50% required for body maintenance in ruminants (Ammann et al. 1973). In contrast, protein content, although varying with forage species and individual plant parts, is estimated at 7.0–8.0% in Elk winter diets on the Island (Janz 1983), exceeding the minimum 5.5% level required by a pregnant cow (Nelson and Leege 1982). However, protein levels in certain forage species are well below 5.5% (Janz 1983), and so survival and productivity may suffer in Elk forced to restrict their diets to poor-quality forage.

In support of a varied diet, Elk experience seasonal shifts in the types of plants on which they forage as well as their specific foraging areas. Elk rely much more heavily on coniferous forage in winter, whereas shrubs, ferns, and grasses dominate spring and summer diets. Good winter range helps to reduce winter mortality by slowing the rate of energy (fat) loss. High-quality spring range allows Elk to replenish body reserves quickly, and good summer range allows them to rebuild large stores of fat for the upcoming winter. Abundant, high-quality food on one seasonal range can compensate to some extent for poor forage on another seasonal range. Changes in forage quality on one seasonal range can also have a disproportionately beneficial or detrimental effect on the local Elk population.

When only forage of sub-maintenance energy (i.e., <50% digestibility) or protein (i.e., <5.5%) content is available, Elk lose weight rapidly as bodily reserves are used up. Most members of the deer family experience an over-winter loss of weight each year (Nelson and Leege 1982). If forage quality remains low for extended periods, fat reserves will be depleted and catabolism of body tissues may occur to meet the energy deficit. Spring calf production and survival rates are affected when over-winter weight loss by adult cows exceeds 15% (Thorne et al. 1976), and mortality is highly likely when weight loss exceeds 30% (Verme and Ullrey 1972). Calves typically enter their first winter with fewer reserves of energy than adults and usually suffer higher winter mortality rates (Nelson and Leege 1982).

In addition to the nutritional value of habitat, Elk use both vegetative and topographic features to provide security, as well as reduced snow depths and metabolic demands. The first of these, security cover, provides Elk with a sense of security or means of escape from the threat of predators or harassment (Skovlin 1982). The primary factors influencing a stand's value as security cover are the density and diameter of the trees and understorey, which should be capable of hiding at least 90% of a standing animal at 61 m (200 ft) or less to be adequate (Thomas et al. 1979). On Vancouver Island, many coniferous stands with canopy closure of more than 60% will function as security cover if they are 3 m tall and 100 m wide (wide enough to ensure an Elk in the centre of the patch will be hidden from view from all sides). In some instances, a relatively narrow band of trees can provide security, depending on topography and adjacency of other habitats.

Although it is rare for air temperatures on Vancouver Island to fall below –20°C (which has been documented as a critical threshold temperature for Rocky Mountain Elk; Parker and Robbins 1984), wet animals exposed to wind would probably experience thermal stress even at temperatures above freezing (Bunnel et al. 1985). On the coast of British Columbia, thermal cover for Elk is provided by coniferous stands taller than 10 m with more than 70% canopy closure. Stands with these characteristics will ameliorate temperature extremes in both summer and winter and will reduce excessive wind speeds. The dense overstorey canopy will also reduce throughfall of precipitation.

Tree cover that intercepts snowfall allows Elk to move with minimal energy expenditure and take advantage of opportunities to forage on understorey plants that extend through the relatively shallow snowpack. Coniferous stands at least 10 m in height and with a mean canopy closure of 60–90% are relatively efficient at intercepting snow while providing enough light to allow growth of an understorey for forage. Regenerating stands of trees may be strong enough to resist bending and dropping snow during light or even moderate snow falls (McNay et al. 1988). However, during heavy snow falls, old growth is superior in its ability to intercept and hold snow. With their multilayered canopies, large branches, and interspersion of small openings and dense canopy, old-growth stands may be the only habitats capable of supporting Elk through severe winters in moderate or deep snowpack zones. Elk populations declined significantly on southern Vancouver Island during the deep-snow winter of 1968–1969 when old-growth winter range was unavailable (Nyberg et al. 1990).

Elk are an "ecotonal" species, concentrating their habitat use along edges. Many studies have found that Elk use of both forage and cover areas declines as the distance from their common edge increases (reviewed by Witmer et al. 1985). When all seasonal habitats are closely interspersed, groups of Elk can support their requirements within smaller areas and the range can support a larger total population. Close interspersion of habitats is particularly important during calving when pregnant cows will generally separate from the main group to seek secluded areas on the summer range in which to give birth. Forage and cover must be very close together as cows and newborn calves usually remain in an area of 1 ha or less for 10 days to 3 weeks after birth before rejoining larger groups. Cows tend to calve in similar habitat each year, although variable spring weather and/or snow conditions may prevent repeated use of the same site.

Like many other ungulate species, Elk are attracted to salt, but the regular use of "mineral licks," or exposed areas of saline soil, is believed to be a habit-formed luxury (Skovlin 1982). Schwartz and Mitchell

Table 1. Winter range capability and suitability for Roosevelt Elk on Vancouver Island.

	Capable Habitat		Suitable Habitat		
Habitat Class	Area[a] (km^2)	% of Total Available	Area[a] (km^2)	% of Total Available	% of Capable Habitat Currently Suitable[b]
High	2,699	8	261	1	10
Mod. high	4,066	12	650	2	16
Moderate	11,309	34	8,450	25	75
Low	5,885	18	7,151	22	122
Very low	5,725	17	13,163	40	230
Nil	3,504	11	3,512	11	100
Total	33,188	100	33,187	101[c]	

[a] Areas are derived from habitat ratings given to broad ecosystem units mapped at 1:250 000 scale. For polygons containing multiple ecosystems of differing capabilities, the proportion of area occupied by each separate ecosystem is included. Data were not available for 130 km^2 of habitat.

[b] Calculated by amount currently suitable ÷ amount capable x 100.

[c] Calculation exceeds 100% due to rounding error.

(1945) reported that Roosevelt Elk on the Olympic Peninsula in Washington had little interest or need for salt. On Vancouver Island, Elk have shown little interest in salt blocks at trap sites during attempts to capture animals for relocation.

Trends

When evaluating trends in habitat supply, it is important to consider that while seasonal ranges tend to be used traditionally, specific areas may be used to varying degrees (or not at all) in different years because of annual variation in weather conditions and Elk behaviour. Summer ranges are probably least affected by this phenomenon, but during particularly hot summers, areas providing relief from thermal stress will receive more use. Spring ranges usually show the greatest variability in location and time of use of the three seasonal ranges (winter, spring, and summer/fall). A gradual loss of the winter snowpack results in a longer period of use of spring range, whereas a rapid snow melt after a mild winter may result in Elk using spring ranges for only a short time, if at all, before migrating to summer range. Similarly, use of winter range will vary with winter severity. Elk may not require old-growth forest to last through milder winters, but high-quality winter range will be much more important in areas or years with moderate or deep snowpacks. Winter is the most critical season for Elk: bulls are weakened from the rut, calves are susceptible to malnutrition, energetic demands are high, and forage quality is poor. For this reason, discussion of habitat trends will focus almost exclusively on winter range.

Several sources of information suggest a negative overall picture of the status and trend of Roosevelt Elk winter habitat in British Columbia. Broad-scale ecosystem mapping — in which ecologically based polygons on 1:250 000 scale maps are rated by a team of regional biologists for their potential capability and current suitability — provides an indication of how well habitat is being managed for Elk (Figures 4 and 5). A broad-scale comparison of the winter range capability and suitability of the ecosystems in southwestern British Columbia suggests a large difference between the number of Elk that the habitat is capable of supporting and the number that it currently supports (Figure 2). On Vancouver Island, habitat is well below its capability throughout most of the Roosevelt Elk range, with only a small part of high- and moderately high-capability winter range in which suitability equals capability (Table 1). Much of the Island's capable Elk winter range is well below potential, with only

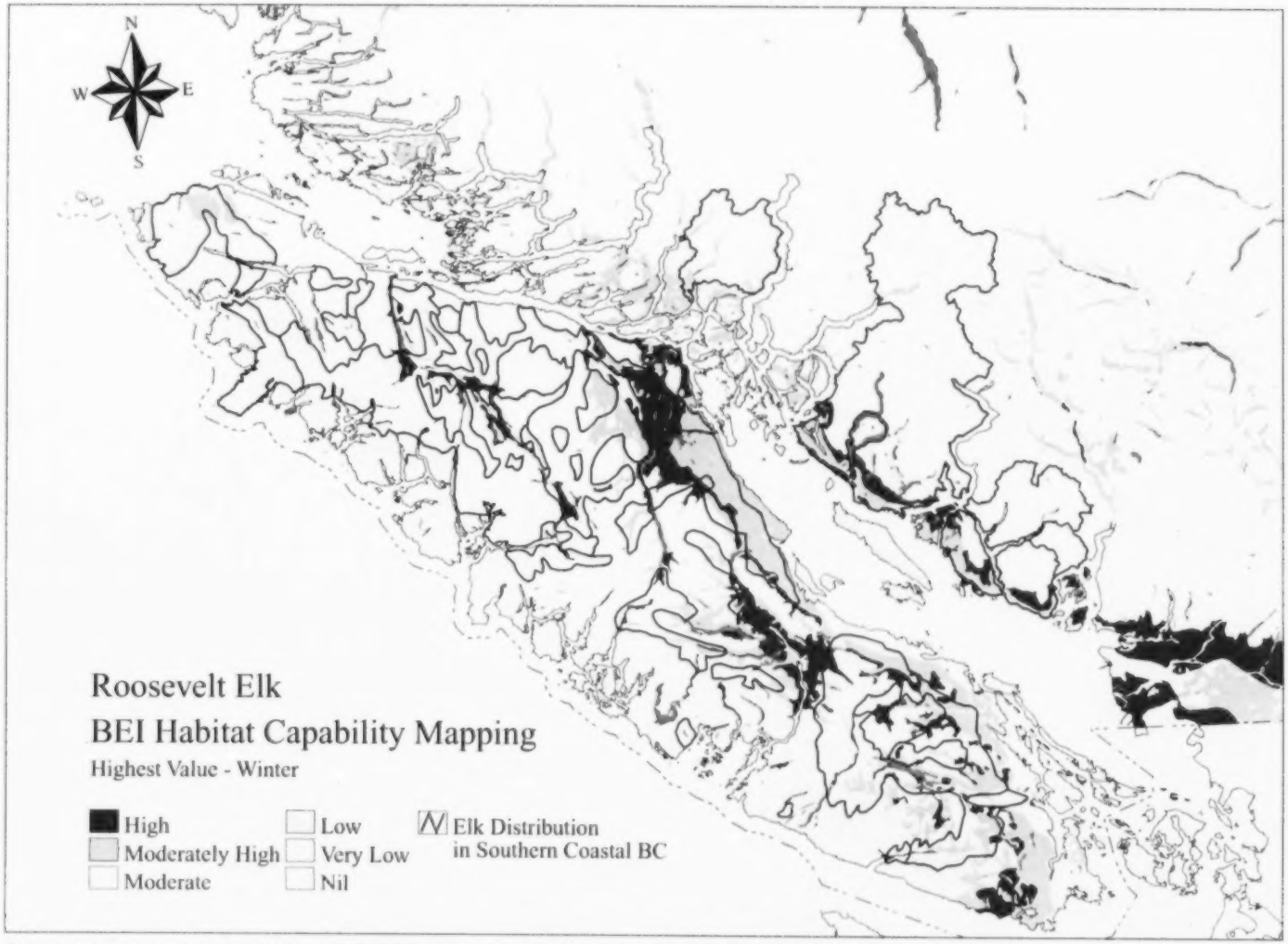

Figure 4. Winter habitat capability for Roosevelt Elk in British Columbia. Capability represents what the habitat is capable of supporting under *ideal* conditions. For polygons containing multiple ecosystems of differing capabilities, the highest value ecosystem is shown.

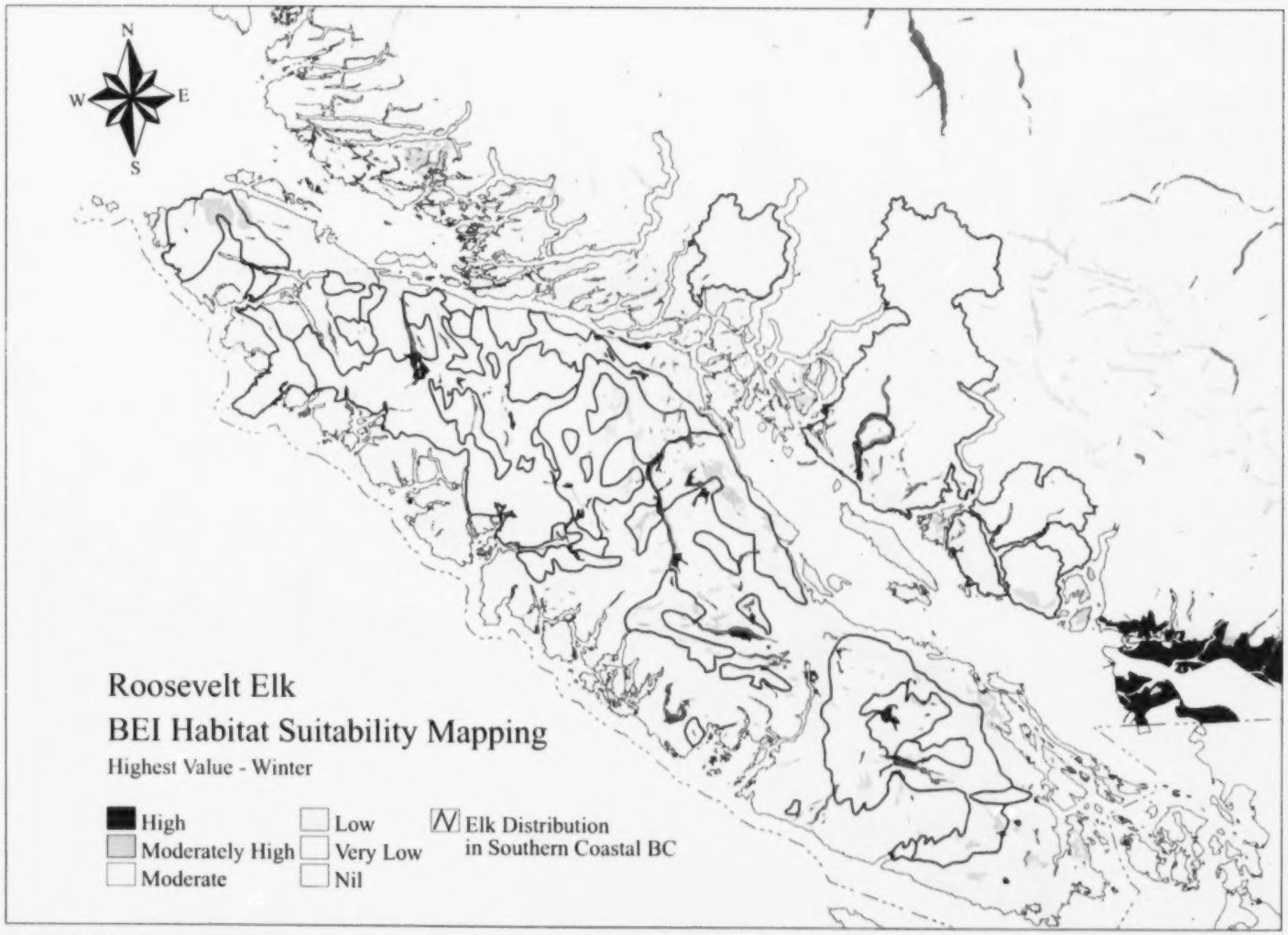

Figure 5. Winter habitat suitability for Roosevelt Elk in British Columbia. Suitability represents what the habitat is capable of supporting under *current* conditions. For polygons containing multiple ecosystems of differing suitabilities, the highest value ecosystem is shown.

an eighth (13%) of high and moderately high winter range operating at its capability. As well, low and very low suitability winter habitats are overrepresented in term of capability — there is currently twice as much very low suitability winter habitat as the capability of the landscape dictates. It would be inappropriate to equate habitat capability with the past state of Elk habitat, but the general difference in capability and suitability, particularly in high- and moderately high-quality winter range, suggests that Elk winter habitat is clearly not being managed to maximize its capability.

Forest harvesting has been largely responsible for the loss of high-quality Elk winter range on Vancouver Island. High-quality Elk winter range occurs in old forest along valley bottoms or riparian corridors, so Elk needs may conflict with the interests of industrial forestry. Regional biologists suggest that most of the prime Elk winter range on Vancouver Island was logged before the 1970s. Annual forest harvest statistics for Vancouver Island, available for the years 1981–2000, range between 3906 and 22 892 ha per year (<1% of the total forested landbase on Vancouver Island, based on provincial baseline thematic mapping), averaging about 13 733 ha per year (<0.5% of the total forested landbase) (unpubl. data, B.C. Ministry of Forests, Forest Practices Branch, 2002). Considering that old-growth forest, which may be critical for Elk in severe winters, takes more than 150 years to develop, annually harvesting a very conservatively estimated 0.5% of the forest will have implications for the availability of Elk winter range in the long term. Forest harvesting does not occur randomly, but rather targets sites based on accessibility and the quality of timber. Since valley bottoms and riparian areas with large trees are favoured by wintering Elk, this suggests that the real proportion of the remaining Elk winter habitat that is logged annually is more than 0.5%.

Much of the highly capable winter range for Roosevelt Elk coincides with the main urbanization and transportation corridor on the Island, along the well-populated east coast and the newly expanded Island Highway from Victoria to Campbell River. Fragmentation, road mortality, and access for poachers are potential issues throughout much of the south Island. Road densities of 1–2 km of roadway/km^2 are common in many watersheds in the central Island, and densities exceeding 2 km of roadway/km^2 occur along much of the southeastern coast (unpubl. data, B.C. Ministry of Sustainable Resource Management, Decision Support Services, 2002).

Protection / Ownership

Several provincial parks provide protected habitat for Roosevelt Elk. On Vancouver Island, the largest is Strathcona Provincial Park, spanning approximately 230 000 ha of mainly mountainous terrain. A portion of the park, perhaps 20%, is regularly used by 200 to 250 Roosevelt Elk, some of which winter outside of the park (Sovka 1990; R. Simmons, B.C. Parks, Parksville, pers. comm.). A draft management plan for the park identifies a need to maintain Elk in their present distribution and abundance as well as for them to recover in areas that were historically occupied (B.C. Ministry of Environment, Lands and Parks 1990). Other provincial parks, such as those on the Brooks Peninsula or at Cape Scott on the northern tip of Vancouver Island, offer some protection of habitat for small numbers (20–30) of Elk each. The new Tahsish-Kwois Provincial Park contains some good Elk habitat and a herd of 30 to 50 animals.

Under Section 69 of the B.C. Forest Practices Code, ungulate winter ranges are to be permanently established by 2003. Provincial ministries are currently working to delineate these ranges for all of the province's ungulates by the deadline, which makes it difficult to get valid estimates of the current status of Elk winter ranges on the Island. Preliminary Figures, representing the amount of land area "netted out" or excluded from the timber harvesting land base for Elk winter range, are available for the seven main tree farm license areas (TFLs 6, 19, 37, 39, 44, 46, 47) that include Roosevelt Elk winter habitat on Vancouver Island. These seven TFLs account for approximately 1.4 million ha, or 40% of the Island's area. Cumulatively, they contain 2680 ha of designated Elk winter range (about 0.2% of their total area).

It would be wrong to conclude that these area values describe the final extent of Elk winter range

protection on Vancouver Island because the designation of ungulate winter range continues. For example, an additional 870 000 ha of timber supply areas (TSAs) on the Island are managed by the province, and not included here because planning is still underway (R. Dolighan, B.C. Minist. Water, Land and Air Protect., Nanaimo, pers. comm.; J. Andres, B.C. Minist. For., Campbell River, pers. comm.). As well, there are opportunities to designate winter range exclusive of Section 69 of the Forest Practices Code through Old Growth Management Areas, Riparian Management Areas, and other land-use planning processes. However, to date, alternative processes have not advanced as far as the work under Section 69. Recently established protected areas that may contain winter range are not included in this calculation, nor are areas designated as winter range for deer, although less than 10% of designated deer winter ranges appear to have any value for Elk (K. Brunt, pers. obs.).

Although it is acknowledged that the 2680 ha of Elk winter range that makes up the currently designated winter range for Elk is incomplete, it is easy to speculate that the amount of Elk winter range to be protected under Section 69 by 2003 will be relatively small. Wildlife biologists involved in the winter range designation process expect relatively conservative gains in the final amount of Elk range protected under Section 69. Even if the final total for the Island is five times the current known value, this could only protect about 5% of the high-capability winter range on Vancouver Island. This, of course, would require that all designated ranges occur in high-capability Elk winter habitats, which is unlikely. Thus, although Section 69 may have raised the priority of conserving Elk winter range on Vancouver Island, the Island's forests reflect the past where timber harvesting and economic values usually took priority over Elk values.

Land tenure is also relevant. Some of the most valuable Elk winter ranges on southeastern Vancouver Island that have been or will be logged occur on private land (D. Janz, B.C. Minist. Water, Land and Air Protect., Nanaimo, pers. comm.). Currently there are no legal provisions to protect Elk habitat on private land.

BIOLOGY

Social Behaviour

Elk are highly social animals, usually banding together into groups of adult and yearling cows, calves (<1 year old), and yearling bulls. More than 100 Elk may congregate in one of these groups, which may be dynamic, breaking into smaller groups and then aggregating again. These groups may be referred to as a herd; however, for management purposes, and within the context of this report, a herd, or local population, is considered to be all the groups that occur within a watershed (Brunt 1990). Each local population of Elk is included in one of three metapopulations in British Columbia: the north Island, south Island, and mainland coast.

Branch-antlered bulls generally remain apart from cow-calf groups, often forming bachelor groups of similar-aged individuals except during the breeding season in September and October. Elk are polygamous and dominant bulls will defend a harem of up to 30 females for exclusive breeding rights. Male Elk will bugle, emitting a hollow, squealing call as a challenge to other bulls. Rutting males who accept the challenge will posture, strut, and occasionally fight using their massive antlers.

Antler size is a key factor in determining a bull's status to breed. Yearling or "spike" bulls (named for their typically long, single-point antlers) and two-year-olds or "raghorns (named for the ragged appearance of their antlers, which frequently have broken tines) are sexually mature but will frequently be excluded from breeding by larger, more dominant animals. Generally, bulls are not considered fully mature until year four, at which point they usually carry antlers with five or more points per side. When bulls are relatively equal in size, antlers are used in a pushing match to establish dominance, potentially resulting in the injury or death of one of the combatants. The potentially high cost of this sparring means that it is avoided when possible in favour of less dangerous competition, such as visual display.

Large mature bulls shed their antlers in the very late winter or early spring, while younger males may carry theirs until late spring. Immediately after the antlers are shed, a new, usually larger pair will begin

growing. Antlers grow extremely quickly, and abundant high-quality summer forage is necessary to maximize their development (Bubenik 1982).

Reproduction

Cow Elk generally conceive for the first time in their third year. Although Elk in very good physical condition may breed at 1.5 years of age (Trainer 1971), Janz and Becker (1986) found none of the yearling cows sampled on Vancouver Island were pregnant. About 90% of mature cows become pregnant during favourable conditions, which includes mild winters, good habitat quality, and an adequate supply of mature bulls for breeding. Although they are sexually mature as yearlings, in Elk populations with high bull density as in coastal British Columbia, bulls are generally excluded from breeding until their fourth year.

A single calf is born in late May or early June after a gestation period of about 255 days (Trainer 1986). Twin calves have never been confirmed on Vancouver Island. Cow Elk will usually produce one calf each year, starting on their third birthday and then throughout their life, which may last up to 20 years. Cows give birth in solitude, apparently to separate themselves from highly visible groups of Elk and the predators they attract. Calves will remain hidden until 10 days to 3 weeks old, by which time they have gained sufficient mobility to rejoin a larger group. Summer calf to cow ratios from inventories on Vancouver Island may range from 40 to 60 calves per 100 cows (K. Brunt, unpubl. data). Spring calf to cow ratios typically range from about 20 to 50 calves per 100 cows, depending primarily on predation and winter severity.

Reproductive success in Elk can be influenced by a number of factors, including winter severity, predation, disease, and parasites that affect pregnancy, birth rates, and calf survival. The key factor, however, is the nutritional condition of the cow. High-quality habitat allows Elk to build abundant reserves of energy (in the form of body fat) from spring through fall, and also slows depletion of reserves in winter. Populations in good physical condition have higher pregnancy rates and a larger proportion of breeding yearling and 2-year-old females (Trainer 1971), and calves born to cows that have access to high-quality forage weigh more at birth, improving their chances of survival (Thorne et al. 1976). Calves fed on rich milk and abundant, nutritious forage will also have more fat reserves at the onset of their first winter. Where winter range is extremely poor, pregnant cows may abort during gestation (McNeill 1972).

Survival

Life table data (Janz and Becker 1986) suggest 6.9 years as the generation length for Roosevelt Elk on Vancouver Island. Maximum life expectancy of Elk on Vancouver Island is about 22 years for a cow and 18 years for a bull, although average life expectancy is typically about half of these values. Bulls tend to have a higher rate of mortality because of hunting and as a result of overwinter mortality from post-rut exhaustion before winter (Flook 1970). In terms of age classes, mortality is highest in juveniles, with as few as 30% of Elk surviving their first year, even during relatively mild winter conditions (Janz and Becker 1986). Fewer calves will survive more severe winters, particularly on poor range.

Telemetry studies provide some insight into natural causes of mortality in adult Elk, including predation and both regulated (or legal) and unregulated (or illegal) hunter harvest (Table 2). Based on this sample, natural predation appears to have less impact than human-induced mortality. However, it is difficult to assess sex-selective causes of mortality because the male portion of the population is not well represented.

Movements / Dispersal

The annual range of a herd of Elk is usually similar from year to year. Most Elk on Vancouver Island are migratory; they occupy three distinct seasonal ranges in the winter, spring, and summer/fall periods. Migratory Elk benefit from relatively shallow snow depths on low-elevation winter ranges and abundant, diverse forage on higher elevation summer ranges. Also, because the elevation gradient and variety of aspects available on mountainous summer ranges provide Elk with access to forage at various stages of phenological development, Elk can obtain succulent, newly emerging forage when many lower elevation

Table 2. Causes of mortality in Vancouver Island Roosevelt Elk inferred from telemetry studies.

Source	No. of Collared Animals	Predation (predator)	Hunter Harvest	Illegal Harvest
Brunt 1991	6 AF[a]	–	–	4 AF
Sovka 1990	10 AF	1 AF (wolves)	1 AF	–
Koshowski and Brunt 1998	22 AF[b] 4 SAF 3 AM 2 SAM	1 AF (unknown)	2 AF 1 SAF	–
Totals (%)	47	2 (4%)	4 (8%)	4 (8%)

AF=adult female; AM=adult male; SAF=subadult female; SAM=subadult male.

[a] 8 AF were actually collared. Two died of capture myopathy and were excluded from this analysis.

[b] 23 AF were actually collared. One died of capture myopathy and was excluded from this analysis.

plants have already matured and desiccated. Migration, however, increases costs of locomotion and vulnerability to predation, so a net gain must be realized from migration for it to be a viable strategy. The annual range of migratory Elk is simply the sum of all seasonal ranges and the routes that connect them.

Nonmigratory or "resident" Elk also occur in favourable low-elevation habitats, but the larger number and size of the migratory herds suggests that migration provides a significant advantage in some areas. Resident Elk herds occupy single ranges of about 5–10 km^2 at low elevations that satisfy all seasonal requirements and that sometimes overlap the winter ranges of migratory herds. Seasonal shifts in areas of concentrated use usually occur with seasonal changes in requirements for forage and cover. For example, on Vancouver Island, seepage sites (where skunk cabbage occurs) are often heavily used in the early spring, while densely canopied stands that provide thermal cover are used most heavily during the summer and winter when thermal stress is greatest. The distinct landscape of the Mainland coast, comprised of flat-bottomed, steep-sided valleys, appears to provide little incentive for Elk migration because of the abundance of low-elevation habitat where snow is generally absent and forage plentiful. Similarly, Roosevelt Elk in Oregon, California, and parts of Washington do not exhibit definitive migratory characteristics (Harper et al. 1987), whereas Elk on the Olympic Peninsula (in Washington) and Vancouver Island, where low-elevation winter range is less plentiful and higher elevation productive summer range more plentiful, tend to be migratory.

The seasonal ranges of a migratory herd are usually within the watershed of a single river, but can be separated by as much as 40 km. Individual seasonal ranges may be up to 30 km^2. Winter ranges, usually occupied from November through March, occur at elevations from sea level to 600 m. Spring ranges are occupied for varying periods from February through to April, depending on the timing of snowmelt and the spring flush of new forage growth. They may be part of or adjacent to winter or summer range, or occur at some point along the migratory route between the two. Spring ranges may also account for the entire migratory route between winter ranges and summer ranges. Summer ranges usually occur at elevations between 400 and 1500 m and are occupied for varying periods from late spring through to fall (April to November).

Migration to winter range is usually completed over several weeks and seems to be triggered by decreasing forage quality and availability on the summer range as the growing season ends and snow covers the forage plants. During spring migration, Elk follow the retreating snow line and emerging forage to their summer range, where more abundant and nutritious forage allows them to replenish body reserves depleted

during winter. Calves learn the location of seasonal ranges and the migratory routes that connect them from their mothers or the groups with which they are associated (Geist 1982). Individual Elk usually make use only of part of the herd's seasonal range and show fidelity to their own seasonal home ranges, returning to them repeatedly in successive years. Seasonal ranges are usually large and may change over time as habitat quality or population density changes.

Most dispersal from established herds is by sexually mature but subordinate males who leave to find areas of higher quality forage (Geist 1982), or areas where there is less competition for breeding opportunities. Mature cows may disperse to form new herds in response to local carrying capacity, dispersing when the local herd exceeds its resources (Brunt 1990).

Nutrition

Elk are exceptionally flexible ruminants, as evidenced by their capabilities to inhabit such diverse areas as prairies and rain forests (Murie 1951) and to use different vegetative strata, including grasses, forbs, browse, and bark (Bubenik 1982). Elk meet their food requirements by selecting from a wide variety of potential forage species based on availability, digestibility, nutrient concentration, and palatability. Variations in these factors lead to seasonal shifts in foraging areas and the selection of major classes of forage.

Winter diets are typified by a lower diversity of forage items than other seasons. In mild winters with little or no snow, Elk on Vancouver Island rely heavily on grasses, sedges, deer fern (*Blechnum spicant*), and twinflower (*Linnaea borealis*). Plant species associated with wetter sites, such as willow (*Salix* spp.), cottonwood (*Populus balsamifera*), elderberry (*Sambucus racemosa*), and devil's club (*Oplopanax horridus*), are commonly eaten throughout the winter, as are shrubs like salal (*Gaultheria shallon*), Oregon-grape (*Mahonia* spp.), red huckleberry (*Vaccinium parvifolium*), and oval-leaved blueberry (*Vaccinium ovalifolium*). When snow accumulation exceeds 30 cm, conifers become more prevalent in Elk diets; western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) can make up 40% of the late winter diet if snowpack persists.

Spring and summer diets have much larger components of grasses, shrubs such as salmonberry (*Rubus spectabilis*) and red elderberry, and herbs like bunchberry (*Cornus canadensis*), and deer fern and sword fern (*Polystichum munitum*). Both spring and summer diets are typified by a high content of protein and digestible energy. Toward late summer, when annual plants begin to die back, Elk will increase the proportion of conifers they eat. Amabilis fir (*Abies amabilis*), western hemlock, and western redcedar are usually preferable to Douglas-fir (*Psuedotsuga menziesii*) (Brunt 1990).

As with Columbian Black-tailed Deer (*Odecoileous hemionus columbianus*), which are abundant throughout Roosevelt Elk habitat, the four-part stomach of Elk allows them to obtain nutrients by digesting complex carbohydrates such as cellulose from vascular plants. Because the rumen to body weight ratio is higher in Elk than in deer (Hanley 1982; Bunnel and Gillingham 1985), Elk are able to digest relatively larger amounts of coarse forage without running short of incoming energy. They can therefore eat more low-energy foods than deer, particularly grasses, sedges, and coniferous foliage during fall and winter (Rochelle 1980; Janz 1983; Brunt et al. 1989). Although some dietary overlap occurs, direct competition for forage between deer and Elk does not appear to occur (Brunt 1990). Black-tailed Deer are in decline throughout much of the current range of Roosevelt Elk (B.C. Minist. Water, Land and Air Protect., Nanaimo, unpubl. data).

Adaptability

Geist (1982) describes the Elk as an Old World species that apparently entered the "vacuum" left by megafaunal extinctions in North America after the last great glaciations (11 000 years ago). As a result, he believes, the species has not yet had time to evolve a close fit between its adaptive strategies and environment, as evidenced by minimal changes in physiology and morphology of Elk across the wide range of habitats they occupy. Elk have relatively large brains for cervids, and Geist (1982) suggests that because Elk evolved in regions with highly diverse seasons and in contact with a wide array of other megafauna, they adapt to new situations through learning.

The adaptability of Elk is well illustrated in their interactions with humans. Elk will readily adapt to the regular presence of people, and farms of domesticated Elk are common in Alberta, Saskatchewan, and Manitoba. If not disturbed, Elk will accept the regular presence of people within their vicinity, as evidenced by the Elk routinely seen in townsites in Canada's Rocky Mountain parks. There has even been some suggestion that "urban" Elk with calves in tow will choose the comparative safety of predator-free townsites — despite the associated noise and disruption — over wilderness where predation poses a greater risk. A similar situation of Elk and people living side-by-side is developing on the Sechelt Peninsula on the mainland, a setting of increasing urbanization, in which logging roads, golf courses, and subdivisions occupy a shrinking mosaic of habitat for an estimated 200 Elk. Despite the level of human activity, recent aerial surveys suggest that the local population of Roosevelt Elk on the peninsula is stable and probably growing. Sechelt Elk continue to reside within the increasingly human landscape of the peninsula rather than dispersing to the many thousands of square kilometres of easily accessible and sparsely occupied habitat in the surrounding area. As an example of the tolerance of Elk for humans, a large (>400 kg) bull is regularly seen in a small park near the town of Gibsons and will even allow curious onlookers to come within 12 m (D. Reynolds, pers. comm.). It is worth noting that the original Elk introduced to the Mainland from Vancouver Island were considered "nuisance" animals because of their affinity for agricultural lands and other human settings.

POPULATION SIZES AND TRENDS

Approximately 3660 Roosevelt Elk occur in British Columbia (Table 3). Most, about 3300 animals, occur on Vancouver Island where they form two stable metapopulations composed of 120 local population units. These local populations are based largely on watersheds, which roughly equate with individual herd boundaries. Twenty-six units, totalling 560 Elk, make up the south Island metapopulation; 94 units, a total 2730 animals, make up the north Island metapopulation. An additional 375 animals in 15 local populations live on the coastal mainland where Roosevelt Elk numbers are considered to be increasing (Figure 6). Most of the local populations in each metapopulation are small, containing fewer than 25 animals (Figure 7). More than two-thirds of the province's Roosevelt Elk live north of Courtenay on Vancouver Island, and about 80% of these form a stable collection of local populations at the widest, or north-central part of the Island (see also Figure 2). This core area includes several prominent watersheds, including those of the Nimpkish, White, Tsitika, Adam, Eve, Salmon, Heber, and Gold rivers.

All of the local populations in the Lower Mainland are stable to increasing where the demographic trend is known (Table 3), and 69 of the 135 local populations in British Columbia (51%) are stable to increasing. Seventy-three percent of the animals in British Columbia are contained within stable or increasing local populations. About six local populations, or 11% of the province's animals, are declining or potentially declining. It is worth noting that the status of 60, or 44% of the province's local populations (accounting for 16% of the total B.C. population) is unknown (Table 3). As well, a large area of "potential habitat" is shown in Figure 6, where Roosevelt Elk may occur, but confirmation has not been possible. Even for local populations where status is indicated, there will be a margin of error. This is particularly true for Roosevelt Elk because their affinity for closed-canopy winter habitat makes them difficult to survey. In a recent study, sightability ranged from 53–66% for collared Elk (66% is generally required for many bias-correcting models) (Keystone Wildlife Research 1997).

In one attempt to address the potential for error, reliability estimates were paired with each local population estimate, based on whether regional wildlife biologists felt the population estimate was within 25%, 50%, or 75% of the true value (Figure 6). These reliability estimates, rolled together local population by local population, suggest a range of 1743 to 5571 Roosevelt Elk in British Columbia. However, these range limits are extreme, because they are based on a scenario in which the maximum error is present in all 120 local population estimates. This is unrealistic, because there are unlikely to be as few as 1743 Elk in British Columbia when observers on sample-based aerial surveys of Vancouver Island have recorded

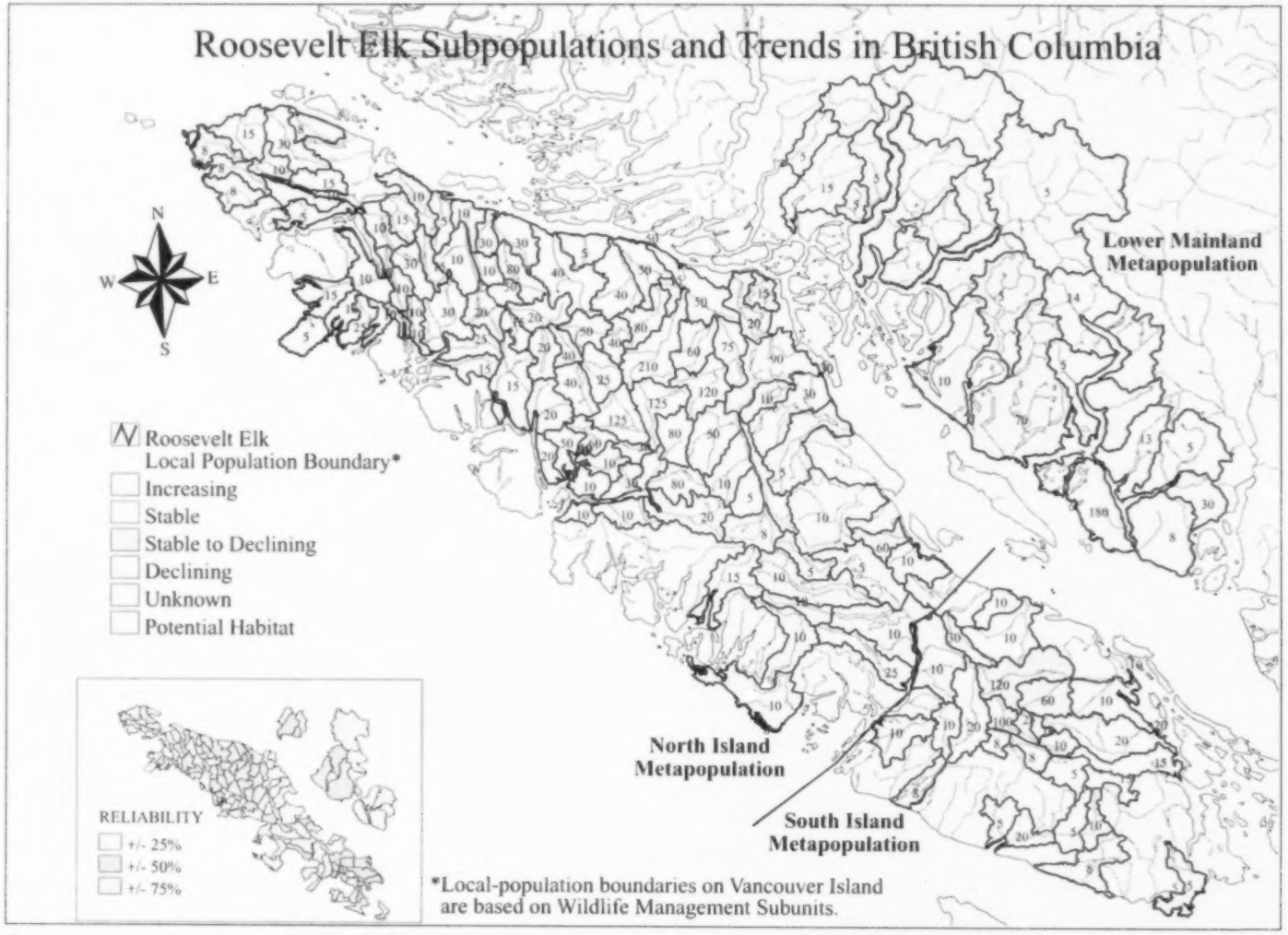

Figure 6. Local populations of Roosevelt Elk in British Columbia, as defined by watershed boundaries. The estimated number of Elk currently occupying each watershed is shown. The inset shows reliability of estimates. Vancouver Island estimates were updated in 2000.

Table 3. Population status of Roosevelt Elk in the three British Columbia metapopulations.

	Population Trend					
	Declining	Declining to Stable	Stable	Increasing	Unknown	Total
Vancouver Island south						
Number of local populations	0	2	13	4	7	26
Number of animals	0	180	176	145	56	557
% of metapop'n	0	32	32	26	10	100
Vancouver Island north						
Number of local populations	3	1	39	0	51	94
Number of animals	160	60	1978	0	527	2725
% of metapop'n	6	2	73	0	19	100
Lower Mainland						
Number of local populations	0	0	5	8	2	15
Number of animals	0	0	52	313	10	375
% of metapop'n	0	0	14	83	3	100
Provincial total						
Number of local populations	3	3	57	12	60	135
Number of animals	160	240	2206	456	593	3657
% of BC population	4	7	60	13	16	100

Local populations are generally defined by watershed boundaries. Trend direction is considered over 3 to 5 years. Vancouver Island estimates updated to 2000.

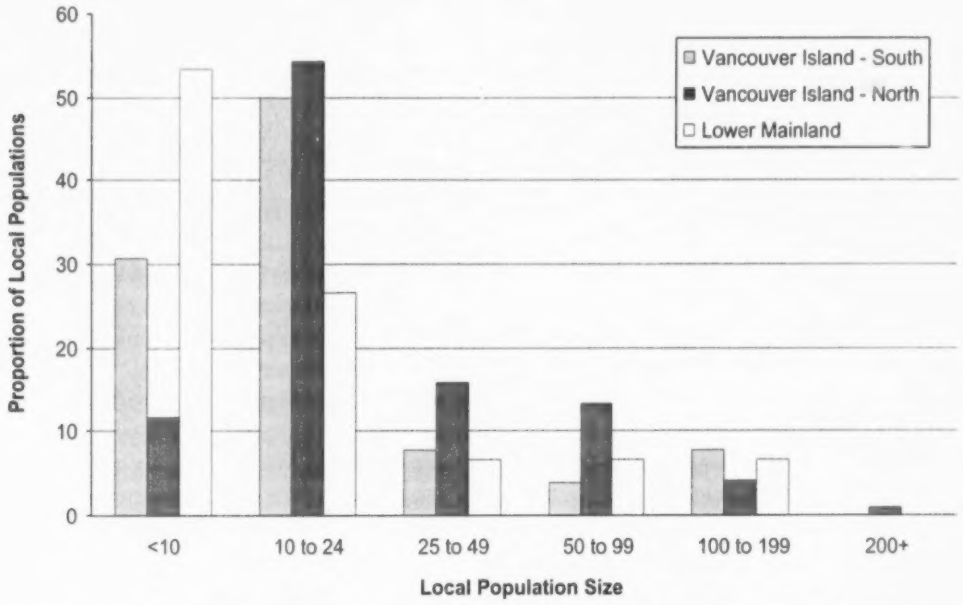

Figure 7. Proportion of local populations within each of three metapopulations, by size of the local population. Vancouver Island estimates were last updated in 2000.

observations of more than 1000 animals collectively in a single year (K. Brunt, pers. obs.). As an alternative, the official provincial estimate for Roosevelt Elk, expressed as a range with no central tendency, suggests there are between 2650 and 4350 animals in British Columbia. This estimate, based on expert opinion (as are all previous provincial estimates), was used to provide outside limits for current Roosevelt Elk numbers in British Columbia (Table 4).

Periodic provincial estimates suggest that, overall, Roosevelt Elk metapopulations are stable to increasing (Table 4). Associated estimates of local population trends (Table 3), especially in the Lower Mainland where current estimates exceed provincial range estimates, suggest that an overall increase in numbers is not inconceivable. However, this should not be viewed as conclusive in itself, because provincial estimates of some ungulates appear to be subjective to the point where they are influenced more by the improvement of information over time than by actual population change (e.g., BC Mountain Caribou Technical Advisory Committee 2002).

A rough finite rate of increase (lambda) for Roosevelt Elk on Vancouver Island of 1.05 suggests a stable population, leaning toward growth. This value is based on a productivity rate of 26% (Janz and Becker 1986) as well as female mortality (Table 2) due to hunting (4/42 or 9.5%) and additional natural causes (6/42 or 14%). There is no assurance that this calculation represents a cross-section of Elk on Vancouver Island as it is based on a limited, localized sample in select years.

In terms of potential "rescue" effects from populations of Elk across the U.S. border, the nearest location is the Olympic Peninsula, separated from Canadian populations by Juan de Fuca Strait, a near-impassable barrier to movement. Olympic National Park hosts a stable population of 4000 to 5000 Elk, most of which are resident year-round (P. Happe, Olympic National Park, pers. comm.). Any perceived "problems" for the Olympic Elk population occur at the edges of the park because there has been a significant decline in the number of Elk in the surrounding area. Genetically, the barrier to movement between U.S. and B.C. Elk may be more blessing than curse; Polziehn et al. (1998) report that genetic samples taken from Roosevelt Elk on the Olympic Peninsula contain a mixture of Roosevelt and Rocky Mountain Elk haplotypes, possibly as a result of introductions of Yellowstone Elk into the Wenatchee Mountains in the early 1900s. Similar samples from Vancouver Island contain no Rocky Mountain haplotypes because the Island population has never mixed with other subspecies.

Age- and Sex-Specific Trends

The number of mature individuals capable of reproduction was estimated as 66% from life table data (Janz and Becker 1986) and 64% from the previous 5 years of Vancouver Island aerial survey data. In the survey data, the number of spike bulls observed were assumed to represent the number of yearling females. For convenience, the proportion of mature individuals was set at 65%, the midpoint of the two estimates.

Based on 65% as the proportion of mature individuals, the Lower Mainland has approximately 245 mature animals, and the northern and southern Vancouver Island metapopulations have approximately 1770 and 360, respectively. A general guideline of conservation biology suggests that to be effective, a population (or in this case a metapopulation) requires a minimum of 50 individuals in the short term and more than 500 in the long term. Although this guideline has been questioned and its significance for Roosevelt Elk should not be overstated, it emphasizes the importance of the north Island Roosevelt Elk metapopulation to the long-term survival of the species in British Columbia. Nevertheless, Simberloff (1986) suggests that we cannot assign a blanket population size below which rapid extinction is likely, and common sense dictates that a single number should not be diagnostic.

Productivity of Roosevelt Elk on Vancouver Island appears to be increasing, as measured by the ratio of calves per 100 cows in aerial surveys (Figure 8). However, the number of calves seen in aerial surveys is much less consistent in the south Island metapopulation, possibly due, in part, to the reduced total number of Elk observed (the number of animals used to derive ratios ranged from 94 to 416). Although calf production appears to be increasing across the Island, a similar trend is not apparent in yearling (spike) bulls,

Table 4. Population estimates for Roosevelt Elk in British Columbia, 1981 to 2002.

Year	Estimate	Outside Limits	Source
Vancouver Island			
1981	2700	1500–4000	B.C. Ministry of Environment 1981
1992	2500	2200–2800	Demarchi et al. 1992
2002[a]	3400	2400–4000	Estimate: K. Brunt, unpubl. data Limits: B.C. Ministry of Water, Land and Air Protection, unpubl. ranges, 2000
Lower Mainland			
1981	10	5–30	B.C. Ministry of Environment 1981
1992	25	20–40	Demarchi et al. 1992
2002[b]	380	250–350	Estimate: D. Reynolds, pers. comm. Limits: B.C. Ministry of Water, Land and Air Protection, unpubl. ranges, 2000
Provincial Total			
1981	2710	1505–4030	B.C. Ministry of Environment 1981
1992	2525	2220–2840	Demarchi et al. 1992
2002[a]	3800	2650–4350	Estimate: K. Brunt and D. Reynolds, pers. comm. Limits: B.C. Ministry of Water, Land and Air Protection, unpubl. ranges, 2000

Estimates for 2002 are based on Table 3; outside limits are based on provincial range estimates from 2000. Note that the estimated number of Roosevelt Elk in the Lower Mainland exceeds the provincial range.

[a] Estimates are rounded to nearest 100 animals to avoid overestimating precision.

[b] Estimates are rounded to nearest 10 animals to avoid overestimating precision.

which are a measure of recruitment of male Elk into the breeding population. Numbers of spike bulls per 100 cows appear to be fairly constant over time.

Comparison of the number of calves per 100 cows and the next year's spike bulls per 100 cows reveals a weak positive relationship (r^2=0.389, F=5.09, P=0.054, n=10) in the north Island, and an even weaker, less significant relationship in the south Island (R=0.51, F=0.002, P=0.964, n=10). This suggests that something other than calf production is driving recruitment on Vancouver Island. Possible causes of mortality are discussed under "Limiting Factors and Threats."

The proportion of bull Elk observed in aerial surveys has remained fairly stable in the north Island metapopulation at approximately 23 to 32 bulls per 100 cows (Figure 9). This does not hold true in the south Island where the number of bulls appears to have declined quite severely and is not recovering after the relatively severe winter of 1996. Bulls are known to be vulnerable to severe winters after the physically demanding fall rut. Their decline in the south Island may reflect the inadequacy of winter range in the south Island during severe winters. Only a few regulated hunting permits are issued (5 resident, 10 First Nation allocations) for the south Vancouver Island metapopulation, so legal hunting is probably not responsible for the slow recovery rate. However, excessive unregulated harvest is known and suspected in some areas of the south Island.

LIMITING FACTORS AND THREATS

Habitat Modification

The British Columbia coast was originally dominated by old-growth forest, which provides forage and all cover requirements for Elk, especially in riparian areas. Interspersed within old-growth forest are small natural openings due to wetlands, windthrown trees, vegetated

slides, occasional burns and, on the Lower Mainland and Vancouver Island, open Gary oak ecosystems. Forestry and urban expansion along the south coast have created large openings in the forest canopy. Even where these openings may not be permanent, reforestation efforts may work to produce large homogeneous forest stands that contain less structural diversity than natural old growth. Such habitat modification may lead Elk to avoid important habitats, expend excessive energy, or adopt behavioural strategies to cope (Schroer et al. 1988). Past and future changes are discussed in more detail under "Habitat."

Roosevelt Elk are an "ecotonal" species that concentrate their habitat use along the edge between relatively open areas that provide forage and densely forested areas that provide cover (Skovlin 1982). Studies on Vancouver Island have shown that about 50% of Elk use of foraging areas takes place within 40 m of a forage/cover edge, and about 95% occurs within 200 m of such an edge. Similarly, for use of cover, 50% of Elk use occurs within 40 m and 80% within 200 m of the forest edge (Brunt et al. 1989). This pattern of habitat use is attributed to the high diversity of habitat associated with edges, and the opportunity they provide for most or all of the requisites of life. Alteration of the mosaic of forest habitats, such as moving from a pattern of small openings in a matrix of old-growth forest to larger openings and more homogeneous second-growth forest, has had implications for Roosevelt Elk populations. Because Elk must travel farther to meet their daily requirements, they are more likely to encounter

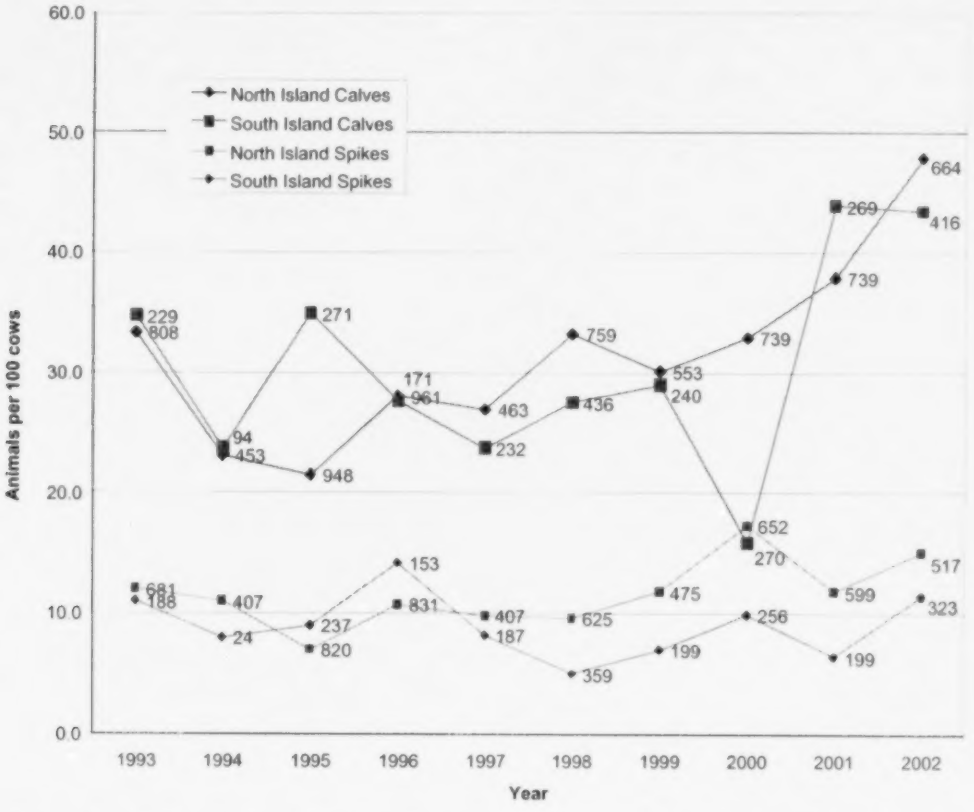

Figure 8. Trends in the number of calves per 100 cows and spikes (yearling bulls) per 100 cows based on late winter/spring aerial surveys of north Island and south Island Roosevelt Elk metapopulations. Numbers indicate sample sizes used to calculate ratios.

predators, roads, private property, and unfamiliar habitat, which may lead to an increased mortality rate.

In addition to changing the habitat mosaic, land-use decisions and human activities have also led to loss of winter ranges. Stands of old-growth forest, are shown by many studies to be preferred by Elk, or at least used in proportion to their availability (Witmer and deCalesta 1983; Jenkins and Starkey 1984; Brunt et al. 1989). Topographic features such as valley floors and lower slopes of valleys that are selected by Roosevelt Elk (Jenkins and Starkey 1984; Brunt 1990) are also popular for human residential, urban, and farm development. Loss of old-growth winter ranges may be less important on the Mainland, where low-elevation habitat is currently so abundant that there appears to be little need for Elk to require old-growth stands to ameliorate winter conditions (D. Reynolds, pers. comm.). However, loss of old-growth winter range is of more concern on Vancouver Island because overwinter mortality is considered the most important source of mortality acting on Island Elk. High-quality winter range may be only a periodic requirement for Elk survival, but during harsh winters, range quality can certainly impose significant constraints on herd size and productivity (Lyon and Ward 1982).

Predators

Wolves, Cougars, and Black Bears occur within the range of Roosevelt Elk. The major predators of adult Elk are considered to be wolves and Cougars (Taber et al. 1982). In three previous telemetry studies in British Columbia, predation has accounted for the death of 4% of all collared animals (2/50), or 20% of all documented mortalities (2/10) (Table 2). Predation is

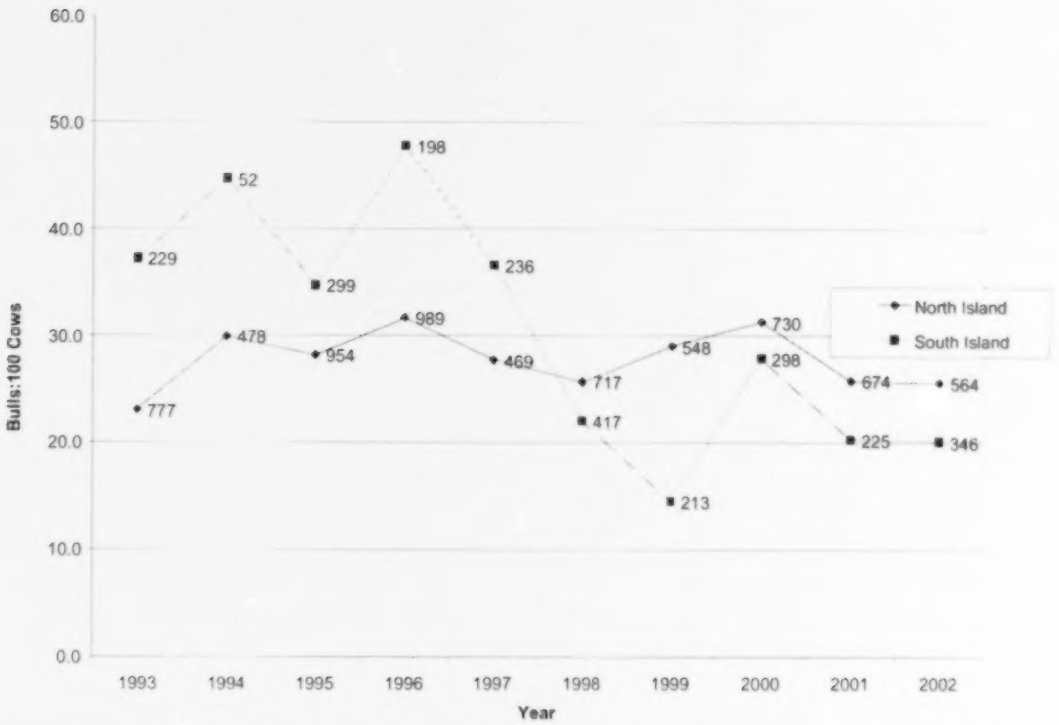

Figure 9. Trends in the number of bulls per 100 cows based on late winter/spring aerial surveys of north Island and south Island Roosevelt Elk metapopulations. Numbers indicate sample sizes used to calculate ratios.

likely responsible for the difference in calf production and spike bull recruitment (Figure 8) because young animals can be particularly vulnerable to predators.

Wolf-caused mortality of a collared adult Elk has been reported in telemetry studies (Table 2), and Elk have been identified by scat analysis as an alternative prey for wolves on Vancouver Island (Scott and Shackleton 1982; Hatter 1988). Wolves on Vancouver Island prey primarily on Black-tailed Deer and have been identified as the cause of deer population decline in some watersheds on the Island (Hebert et al. 1982; Hatter 1984). Janz and Becker (1986) discuss the potential effects of prey-switching behaviours of wolves in light of the current general decline in deer populations on Vancouver Island. They speculate that wolves have the potential to suppress Elk recruitment; they further suggest that Elk vulnerability to predation is influenced by winter severity and the ability of Elk to find adequate, uncrowded winter range. Hebert et al. (1982) and Harestad (1979) suggest that logging may concentrate deer into discrete winter range, making them vulnerable to wolves that will concentrate their hunting activities where efficiency is greatest. Thus, there is potential for wolf predation on Elk to increase if deer numbers on Vancouver Island continue to decline, and to intensify further if an adequate supply and quality of winter range for both species is unavailable. In recent years, low spring calf to cow ratios have been noted in certain Island watersheds where deer populations have declined dramatically but wolf and Cougar levels remain relatively high (K. Brunt, unpubl. data).

Cougars have been reported pursuing and successfully capturing Roosevelt Elk on Vancouver Island (Janz and Lloyd 1977; J. Deal, Canadian Forest Products Ltd., Woss, B.C., pers. comm.). They are also considered the major predator of Elk in neighbouring Washington and Oregon, where wolves are absent. Cougars are abundant on Vancouver Island. Some authors speculate that the Island is home to the highest concentration of cats on the continent (Guiguet 1962). Hornocker (1970) reported that 75% of the Rocky Mountain Elk killed by Cougars in Idaho were younger than 1.5 and older than 9.5 years. A reduced calf crop in annual Vancouver Island Elk surveys may indicate that a similar demographic is targeted by Island Cougars hunting Roosevelt Elk (K. Brunt, unpubl. data). This source of mortality would not be detected by conventional radiotelemetry studies, which tend to collar adult and subadult animals.

Bears have been documented as an effective predator of Rocky Mountain Elk calves. In one study of radiocollared Rocky Mountain Elk calves, Black Bears accounted for the deaths of 28 of 53 calves, whereas Cougars were responsible for only 6 deaths (Schlegel 1976). Although there is some evidence that Vancouver Island bears prey on deer fawns, and that they show great interest in the sound of a deer fawn in distress (H. Davis, Artemis Wildlife Consultants, Smithers, B.C., pers. comm.), no data are available on Elk predation by Black Bears on Vancouver Island. However, anecdotal stories associating bears with calving Elk are not uncommon (D. Janz, pers. comm.).

Linear Disturbance

The development of linear corridors in Roosevelt Elk habitat, generally in the form of paved and logging roads, presents a potential threat to Elk populations. As a broad-scale illustration, the main transportation corridor on Vancouver Island, created by the Island Highway from Victoria to the north Island, bisects high-capability Elk habitat. This creates a barrier to movement for Elk, and may render habitat on the eastern side of the highway inaccessible. In addition to the barriers created by larger roads, overall road densities of 1–2 km of roadway/ km^2 are common in many watersheds in the central Island, and densities higher than 2 km of roadway/km^2 occur along much of the southeastern coast (unpubl. data, B.C. Ministry of Sustainable Resource Management, Decision Support Services, 2002). Lyon (1979) suggests that Elk habitat effectiveness would decline to zero at road densities higher than approximately 1.2 km of roadway/km^2 (2.0 miles per square mile).

In a review of animal response to disturbance, Shank (1979) summarized Elk responses to roads in numerous states. In general, Elk appear to avoid roadways by 200 to 1600 m. In a more recent review of linear disturbance, Jalkotzy et al. (1997) summarized numerous studies, mainly of Rocky Mountain Elk, which demonstrate Elk stress responses to disruption in the form of longer

Table 5. Elk and misidentified "Moose" reported by highway crews as killed by vehicle collisions on Vancouver Island, 1996–2002. There are no Moose on Vancouver Island so these may be Roosevelt Elk. Figures for 2002 are preliminary (source: B.C. Ministry of Transportation).

Year	Elk Reported Killed	"Moose" Reported Killed
1996	4	0
1997	0	0
1998	1	3
1999	8	2
2000	16	0
2001	5	2
2002	4	3
Total	38	10

movements and higher activity levels. However, Elk in forested habitats on Vancouver Island do not appear to avoid habitat adjacent to forestry roads to the same extent as has been documented in other hunted populations in North America, provided adequate security cover is available (Nyberg 1990; D. Janz, pers. comm.). Brunt et al. (1989) found most use of forested winter habitats by radiocollared Elk took place within 200 m of roads, and Elk regularly used a bog habitat within 100 m of an active road but concealed by a strip of forest. Elk were much more noticeably affected by roads in open areas or deciduous stands lacking cover.

Although Elk may tolerate a low level of disturbance associated with roads, there are other impacts that are less tolerable. Unsworth et al. (1993) suggest that unregulated hunting and poaching may increase as a consequence of increased access from new roadways. In recent years, illegal killing has taken a heavy toll on south Island Elk herds (see "Hunting"), and, without roads, Elk would be safer from poachers. Elk also appear to be far more wary of people outside of vehicles than of the vehicles themselves (Shank 1979), and thus direct mortality from vehicle collisions is also a threat (e.g., Holroyd 1979). Road mortality appears to vary with characteristics such as road width and traffic volume (Jalkotzy et al. 1997), and so it is no surprise that after the improvement and expansion of the Island Highway on Vancouver Island, Elk-vehicle collisions sharply increased (Table 5) after the new highway opened in fall 1999. In response, ungulate fencing was erected along certain key stretches of highway and appears to be effective in reducing ungulate-vehicle collisions. Since the initial opening of the expanded highway, ungulate/vehicle collisions have declined and stabilized to about 1/3 of their initial level (or 1/2 of this level, depending on whether misidentified "Moose" are included; Table 5), a pattern common to new highways (Keystone Wildlife Research 2001).

Hunting

Regulation of hunting for Elk in British Columbia began in the late 1800s. It was not long after, perhaps in 1909, that concerns about the welfare of Roosevelt Elk on Vancouver Island led to the closure of the southern third of the Island to hunting for a 5-year period. Excessive market hunting pressure is said to be largely responsible for the near eradication of Elk from the south Island and Lower Mainland (Spalding 1992) that resulted in the closure of Elk hunting on the Island until 1954 (Demarchi et al. 1992).

British Columbia classifies Roosevelt Elk as "big game" under the provincial *Wildlife Act*, while simultaneously classifying them as a vulnerable "blue-listed" species in British Columbia. This may seem paradoxical when liberalized hunting in the past has led to declines in Roosevelt Elk numbers; however, provincial harvest guidelines recommend more conservative management of Roosevelt Elk than of the Rocky Mountain subspecies (B.C. Ministry of Environment, Lands and Parks 1996). As a result, modern limited entry hunts are very conservative,

generally based on harvest rates of 4% of the antlerless population, 7.5% of bulls, or 10% for bow hunts or depredation hunts (where the objective is to reduce local populations where human conflicts are excessive).

Although Elk hunting has continued on Vancouver Island for many years, 2001 marked the beginning of a limited entry hunt for Roosevelt Elk in the Lower Mainland. The response was overwhelming, resulting in the steepest odds for a participant lottery of any limited entry hunt in the province. As part of the hunt, archers were encouraged to pursue nuisance animals by making arrangements to obtain access to private lands.

In addition to resident (limited entry hunts) and First Nations hunting, a very limited number of non-resident hunting opportunities are available through licensed guide/outfitters. Currently, on Vancouver Island, 6 bull and 2 either-sex animals are allocated annually to non-residents. On the Lower Mainland, 2 bulls are allocated to non-residents.

Although total harvest on Vancouver Island appears to have increased over the past 20 years, this is largely due to the inclusion of First Nations allocations in the total after 1993 (Figure 10). Limited entry resident and non-resident harvests have remained quite stable. As indicators of the health of hunted populations, calf to cow ratios appear to be increasing and recruitment appears to be stable over the past 10 years (Figure 8). Bull to cow ratios are also stable in the north Island and well above the provincial minimum 20 bulls per 100 cows guideline used by the Ministry (Figure 9; B.C. Ministry of Environment, Lands and Parks 1996). Hunter success and harvest on Vancouver Island appears to have been stable over the past 24 years, and linear regression of hunter success by year does not differ significantly from zero (Figure 11).

Mortality in the form of wildlife poaching or unregulated hunting appears to be a considerable issue for some Roosevelt Elk herds. Eight percent of radiocollared Elk on Vancouver Island have been illegally harvested, accounting for 40% (4/10) of all

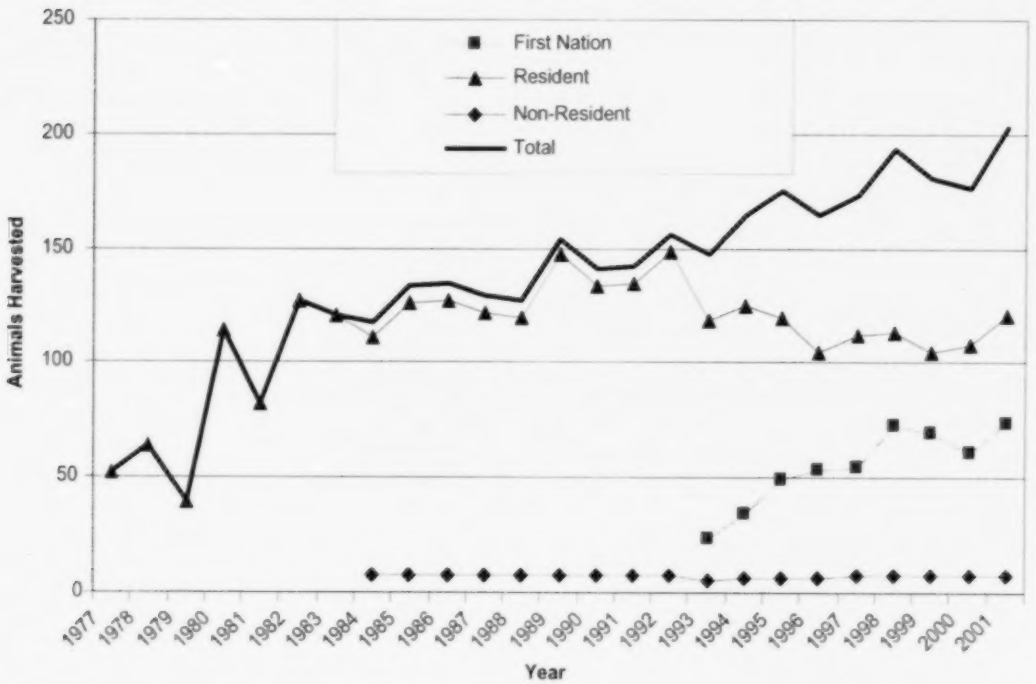

Figure 10. Harvest of Roosevelt Elk on Vancouver Island by resident hunters (limited entry hunt), non-resident hunters, and First Nations. Before 1993, there was no direct allocation to First Nation hunters.

healthy, radiocollared animal deaths — the highest source of mortality, next to legal harvest, in collared Elk (Table 2). Since 1991, 173 investigations have been undertaken by the B.C. Conservation Officer Service of offences involving Roosevelt Elk; 126 of the investigations involved hunting Elk out of season or without a permit. Forty-five enforcement actions have been taken that concern Roosevelt Elk; 11 involved hunting out of season, and 8 involved possession of illegal wildlife (unpubl. data, B.C. Ministry of Water, Land and Air Protection, COORS database, 2002).

Parasites / Disease

No evidence of debilitating parasites or disease infections has been documented in Roosevelt Elk in British Columbia. Roosevelt Elk are hosts to a number of parasites including ticks, tapeworms, lungworms, and liver flukes, none of which appears to have serious pathological consequences or to reduce the ability of healthy animals to reproduce (Blood and Smith 1987). However, to an animal in poor condition, increased parasite loads may lead to a reduced ability to survive adverse circumstances, such as harsh winters (Cowan 1951).

FUTURE TRENDS

Although Roosevelt Elk metapopulations in British Columbia currently appear stable, and may even be increasing in certain areas, the future of Elk on the Island, at the core of their range, will depend on our willingness and ability to effectively mitigate current threats.

In the short term, two threats — unregulated hunting and predation — are particularly notable, but the extent of either is largely unknown. Table 2 provides some indication of the impact of unregulated hunting (accounting for 40% of radio-collared mortalities), and if this is at all accurate, there is cause for concern. Of even

Figure 11. Roosevelt Elk resident hunter harvest and success on Vancouver Island, 1977 to 2001. Straight line regression of success (y=-220.34+1.41x) did not differ significantly from 0 (r^2=0.14, F=0.321, P=0.58). Chart includes antlered, antlerless, and either-sex hunts for limited entry hunters only.

greater concern is the potential for unregulated hunting to increase as more of the Island becomes accessible through industrial roads and backcountry motorized vehicles. Predation may limit Roosevelt Elk populations in the short term. Unlike unregulated hunting, which is tied to human access, it is difficult to speculate whether future developments within the range of Roosevelt Elk will favour predators or prey.

Whether threats come from humans or other species, all interactions with Roosevelt Elk operate within the vital context of their habitat. For this reason, the greatest threat to the viability of Roosevelt Elk in the long term is the fragmentation of their habitat and the destruction of their winter range. The urban landscape continues to expand into Roosevelt Elk habitat, particularly on southern Vancouver Island and parts of the Lower Mainland, and the limited availability of old-growth forest as winter range is reduced by logging. Although it is difficult to account directly for the population effects of broad-scale habitat trends, it is easy to speculate that diminishing habitat quality in the future will only lead to diminishing numbers of Elk on Vancouver Island. In addition to direct effects, such as reduced overwinter survival, the loss and fragmentation of habitat may directly augment other threats: increasing vulnerability to predators, creating problem wildlife situations, and providing greater access for unregulated hunters.

When viewed within this context, continued growth of Elk numbers on Vancouver Island not only seems unlikely, but an overall decline seems inevitable. Given the potential of current threats, we speculate there will be a decline in Roosevelt Elk numbers of at least 10% in the next 20 years, or three Elk generations.

SPECIAL SIGNIFICANCE OF THE SPECIES

First Nations of the Pacific Northwest have a long history of hunting Roosevelt Elk that continues to the present. Traditional native hunters were capable and efficient in their pursuit of Elk, relying primarily on communal drives into snares, pitfalls, nets, and deadfalls (McCabe 1982). Elk products provided food, clothing, implements, weapons, decoration, and a medium of exchange in a subsistence economy. Roosevelt Elk are also prized by hunters for both their meat and the trophy value of their massive antlers. As evidence of this, in 2001, the odds of winning a lottery for a limited entry Elk license on Vancouver Island ranged from 25:1 to 185:1, whereas on the Lower Mainland, odds were higher than 450:1.

In addition to the harvest, Elk also provide wildlife viewing opportunities to non-hunters. Although coastal forests provide Roosevelt Elk with cover throughout much of their range, they are still regularly seen along roadways. Roosevelt Elk provide picturesque viewing, because they are large, easily recognizable, and the bulls sport sweeping, massive antlers.

Recently, the Garry Oak Ecosystems Recovery Team included the Roosevelt Elk in a list of species associated with endangered Garry oak ecosystems (Garry Oak Ecosystems Recovery Team 2002). There has been some speculation that Elk browsing and grazing may have played a role in suppressing the growth of some invasive tree species and competitive understorey plants, thereby increasing the diversity of understorey vegetation. There are currently no scientific data to support this theory.

EXISTING PROTECTION OR OTHER STATUS

Status in United States is secure.

MANAGEMENT RECOMMENDATIONS

1. Roosevelt Elk should be considered a vulnerable species due to their limited distribution, their apparent vulnerability to forestry activities, and the limited amount of their habitat that is legally protected. As well, the genetic "purity" of British Columbia Roosevelt Elk appears to be globally unique.
2. Although currently being confirmed, the amount of legally protected winter range for Roosevelt Elk appears to be inadequate to protect a significant portion of the metapopulations on Vancouver Island. A habitat supply analysis should be completed, when the amount of designated winter range is known, to evaluate whether habitat supply is compatible with long-range metapopulation targets for Roosevelt Elk on the Island

3. Extensive research and management recommendations are available on how best to manage coastal forests for both Elk and deer (Nyberg and Janz 1990). These guidelines provide best practices for forest management in Roosevelt Elk range outside of protected areas. They should be routinely adhered to, with room for well-planned, adaptive management, by foresters working in high-quality Roosevelt Elk habitat.

4. Conservative hunting seasons should be maintained, in conjunction with regular (i.e., annual or biannual) population monitoring. Closure of all hunting in the south Island metapopulation may be warranted if unregulated hunting continues at apparently excessive levels. Regional wildlife managers should continue to work cooperatively with First Nation hunters to set and track overall harvest levels. Strong penalties should be levied against Elk poachers, and local people should be encouraged to be vigilant to illegal harvest and to report suspicious activities.

5. Both forestry and hunting activities should be managed following an ecosystem management philosophy. Given the role of both Elk and deer as prey species for wolves, Cougars, and possibly bears, activities that increase densities of predators and/or reduce densities of deer, may be detrimental to Elk. Habitat changes that influence predator success may also be detrimental to Elk.

6. Efforts to restore Roosevelt Elk to their former range in the Lower Mainland via translocation should continue. Watersheds should be selected to encourage connectivity between local populations. Potential genetic differences between animals in British Columbia and the United States suggest that the two should not mix.

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